



# **2013 Assessment of the Biology, Habitat and Chemistry of Select Streams and Watersheds of Chesterfield County, Virginia**



*Spring Creek Downstream of Old Gun Road West, April 2<sup>nd</sup> 2013*

**Chesterfield County  
Department of Environmental Engineering  
Water Quality Section**

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## **Executive Summary**

This report presents the physical, chemical and biological water quality data collected by Chesterfield County's Department of Environmental Engineering - Water Quality Section for the period of March 28 to April 11, 2013. As a component of Chesterfield County's VPDES Permit VA0088609, Watershed Assessment and Stream Protection (WASP) Program, 15 streams were investigated during the spring of 2013 to assess the condition of county waters.

Benthic macroinvertebrate data for monitored watersheds were analyzed and tabulated. A total of 11,827 individual benthic macroinvertebrates representing 82 distinct taxa were recovered in 2013. From this data set, the 20 most common taxa were identified and tabulated (Table 9). These 20 taxa combined accounted for approximately 94 percent of all organisms observed during 2013. The 20 most common taxa reflected a general condition indicative of fair to moderate water quality within the monitored watersheds.

A summary of the bioassessment categories of the monitored watersheds indicated that 80 percent of sites sampled (n=12) scored in the two lower categories during 2013 (Figure 1). Five sites were classified as "Severely Impaired" and seven were assessed as "Moderately Impaired." One site in the James River watershed (JR-09) exhibited a "Slightly Impaired" bioassessment condition and two sites (APR-02 and APR-03) were assessed as "Non-Impaired" in 2013. The overall best bioassessment scores were noted in the Appomattox River watershed with the characterization of half of the sites as "Non-Impaired."

Site comparisons made using the VSCI score derived "Aquatic Life Use Tiers" and the Chesterfield County bioassessment conditions demonstrated nine sites where the VSCI and Chesterfield County bioassessment categories were similar (60%), five (33%) where the resulting VSCI condition was lower and one (7%) where the resulting VSCI index was higher. A Pearson's Correlation analysis of these 15 observations indicated a statistically significant ( $p < 0.0001$ ,  $\alpha = 0.05$ ) and strong ( $r = 0.90$ ) positive correlation between these two methods.

A summary of the habitat categories of each monitored watershed indicated that the majority of sites (eight) assessed scored as "Supporting" in 2013. Five sites were assessed as "Non-Supporting" and two demonstrated a "Partially Supporting" condition. One reach scored a value indicating a "Comparable to Reference" status.

A comprehensive suite of chemical parameters was collected during 2013. Instream measurements of dissolved oxygen, pH, conductivity/total dissolved solids and temperature yielded values that were within Virginia state water quality standards and normally expected ranges for Chesterfield County during 2013. All dissolved oxygen concentrations were indicative of well-oxygenated waters with values ranging from 6.9 to 13.1 mg/L. Measurements of pH ranged from 6.2 to 7.3 units and temperature readings were normal for the season. No observations of conductivity were greater than

500 $\mu$ S/cm. Hardness measurements ranged from 13.0 to 66.2 mg/L as CaCO<sub>3</sub> and indicated “soft” water throughout the monitored watersheds.

Nutrient concentrations varied among sites and within watersheds during 2013 (Table 11). The median total ammonia value for all sites in 2013 was <0.01 mg/L as N with individual observations ranging from <0.01 mg/L as N at nine sites among all drainages to 0.04 mg/L as N at Fleets Branch (APR-01). The median nitrate+nitrite nitrogen concentration for all reaches in 2013 was 0.17 mg/L as N, with individual measurements ranging from 0.02 mg/L as N at Stoney Creek (APR-02) to 0.99 mg/L as N at Tributary to Michaux Creek (MCX-04). Measureable levels of dissolved phosphorus were observed at eight sites in 2013 ranging from 0.01 mg/L as P at three sites to 0.04 mg/L as P at Roberts Branch (JR-09). The median value observed for all sites assessed was 0.01 mg/L as P. Total phosphorus concentrations ranged from 0.01 mg/L as P at five sites distributed between the James River and Michaux Creek watersheds to 0.08 mg/L at Roberts Branch (JR-09). The median total phosphorus value was measured at 0.02 mg/L as P.

The levels of total suspended solids ranged from <0.01 mg/L at Tributary to the James River (JR-07) to 11.6 mg/L at Roberts Branch (JR-09). Biochemical Oxygen Demand determinations conducted in 2013 were generally low with values ranging from <2.0 mg/L at eleven sites to 15.3 mg/L at the Roberts Branch (JR-09). Fecal coliform densities ranged from 7 MPN/100ml at Tributary to Michaux Creek (MCX-02) to 80 MPN/100ml at three sites: Tributary to James River (JR-07), Tributary to Michaux Creek (MCV-03) and Michaux Creek (MCX-05). During 2013, none of the streams had *E. coli* measurements that were greater than the 235 MPN/100 ml state standard for recreational contact. The *E. coli* densities ranged from 13.5 MPN/100ml at Tributary to Michaux Creek (MCX-03) to 178.5 MPN/100ml at Tributary to James River (JR-05).

## Introduction

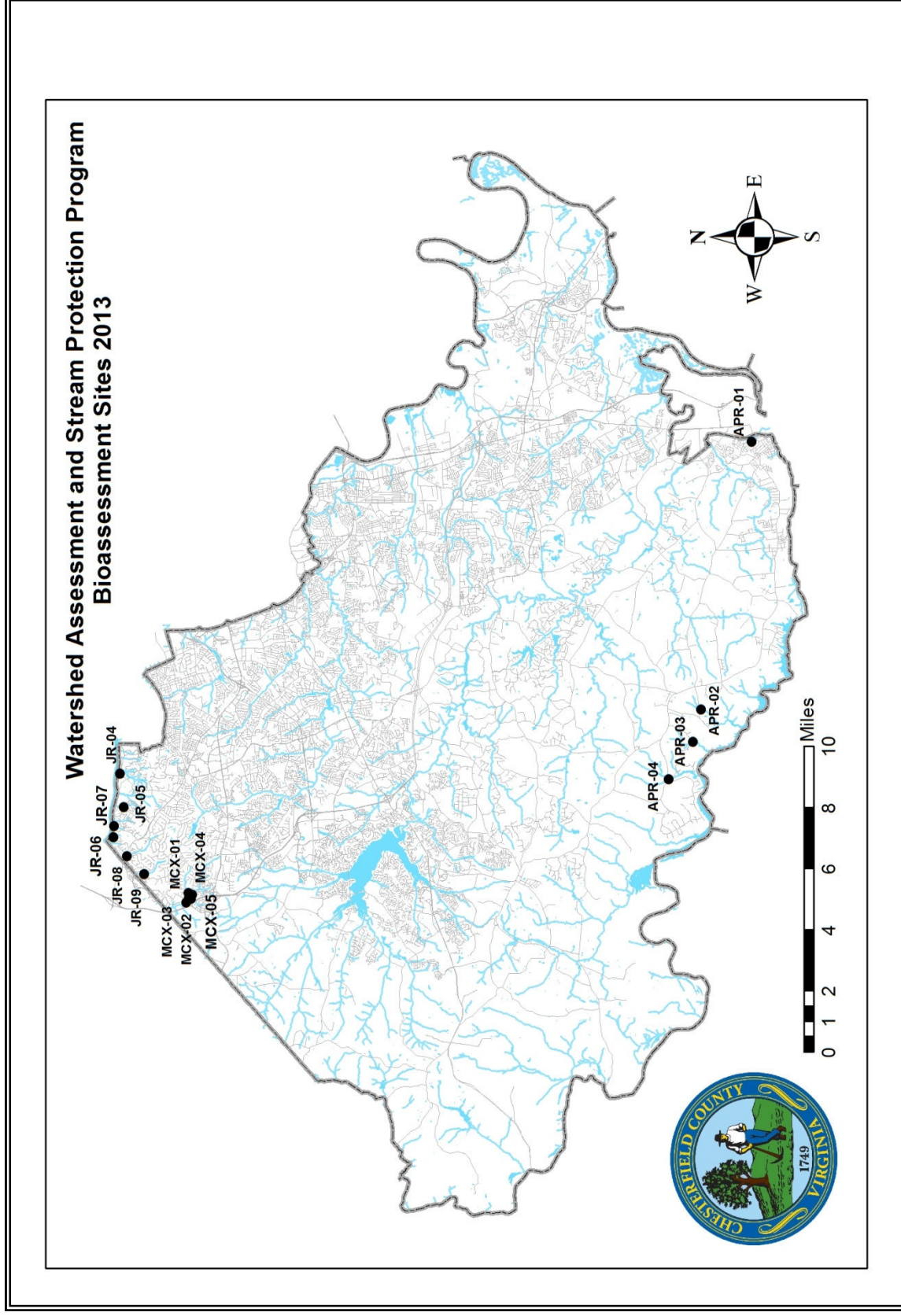
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In 2002, Chesterfield County implemented a watershed-based approach to permit required sampling. Due to observed data inconsistencies and concerns regarding the quality of infrequent sample collection, emphasis was shifted away from the traditional quarterly "end of pipe" stormwater monitoring regime to the comprehensive stream and watershed level assessment procedure. This sampling protocol has remained in effect for the past eleven years with assessed watersheds added on a three-year rotational basis. For the second year, fifteen sites were investigated in three watersheds in 2013; four in direct drainages to the Appomattox River, six in direct drainages to the James River and five within the Michaux Creek watershed (Table 1). Locations of these new sites are depicted in Map 1 on the following page.

*Table 1. Site locations and physiographic data, 2013.*

<u>Site Number</u>	<u>Stream</u>	<u>Station Location</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Stream Order</u>
APR-01	Fleets Branch	On VSU Campus Downstream of East River Road	37.243041	77.419501	1
APR-02	Stoney Creek	Downstream of Trents Bridge Road	37.269374	77.578601	2
APR-03	Tributary to Appomattox River	Downstream of St. Audries Drive	37.273398	77.597667	3
APR-04	Cattle Creek	Downstream of Ivey Mill Road	37.285507	77.619649	3
JR-04	Spring Creek	Downstream of Old Gun Road East	37.555167	77.613086	2
JR-05	Tributary to James River	Downstream of Ashwell Drive	37.553473	77.633059	1
JR-06	Tributary to James River	Robious Landing Park East of James River Road	37.558621	77.651147	2
JR-07	Tributary to James River	Robious Landing Park West of James River Road	37.558378	77.644592	1
JR-08	Marine Spring Branch	Downstream of Kings Farm Drive	37.552002	77.662481	2
JR-09	Roberts Branch	Upstream of Crossings Way	37.543812	77.673236	2
MCX-01	Michaux Creek	East of RT288	37.521841	77.687669	3
MCX-02	Tributary to Michaux Creek	East of RT288 - Upstream of MCX-01	37.520870	77.688152	1
MCX-03	Tributary to Michaux Creek	Southwest of North Otterdale Road	37.523228	77.690353	1
MCX-04	Tributary to Michaux Creek	Downstream of Lasingham Drive	37.522158	77.684781	2
MCX-05	Michaux Creek	End of North Otterdale Road	37.520242	77.685668	3





Map 1. Chesterfield County Bioassessment Sites, 2013.

A critical element of the WASP program has been the reference condition watershed. In 1999 the county's consultant, CH2MHill selected 26 sites within the Swift Creek watershed that were representative of stream size and type as well as land use present throughout the county (CH2M Hill 2000). Benthic macroinvertebrate and habitat data from these sites were used to create a reference condition from which other streams in Chesterfield County could be assessed. These sites were revisited in 2000 by staff from CH2M Hill (CH2M Hill 2001). Water Quality Section Staff continued to sample subsets of these original sites from 2002 to 2005 (OWQ 2004, 2005 and 2006) for further comparison and improvement of the reference condition. Collection of reference condition data and refinement was finalized in 2005 with the establishment of bioassessment and habitat assessment scoring criteria that would be used for future comparisons. In 2006, the monitoring emphasis shifted from the refinement of the reference condition to the use of the finalized reference criteria to investigate sites within different watersheds.

## **Methods**

Stream physical parameters were measured *in situ* by use of a Hydrolab<sup>®</sup> MS5 Minisonde water quality multiprobe in conjunction with a Surveyor 4a data logger system. Parameters measured in the field included dissolved oxygen, pH, conductivity, total dissolved solids and temperature. A semi-quantitative measure of flow was also obtained by recording the time it took for a float to travel a measured distance (one meter).

Water samples for eight permit-required parameters were obtained by county staff from the bank of each site just below the surface of the water by hand. In 2013, analysis for *E. coli* was continued voluntarily to complement the permit-required parameters and to better reflect the current State of Virginia bacterial water quality standards. Appropriate pre-labeled containers specific to each parameter were obtained from the county's contract laboratory (Primary Laboratories Inc.). Samples were immediately placed in a cooler on ice for transfer to Primary Laboratories where sample analysis was conducted. Care was taken in the field and during transfer to adhere to analytical holding times for specific chemistries. Chain of custody forms provided by Primary Laboratories were completed prior to delivery to the laboratory and were signed at sample transfer by each party. Copies were then archived in the Water Quality Section's files for documentation. A summary of the tests, methods and reporting limits is outlined in Table 2.

Table 2. Parameters and Analytical Methods, 2013.

Parameter	Analytical Method	Reporting Limit	Analysts
Dissolved Oxygen	Probe: Hydrolab <sup>®</sup> Minisonde	0.1 mg/L*	Chesterfield County WQS
pH	Probe: Hydrolab <sup>®</sup> Minisonde	0.2 units*	Chesterfield County WQS
Conductivity	Probe: Hydrolab <sup>®</sup> Minisonde	1.0 $\mu$ S/cm*	Chesterfield County WQS
Total Dissolved Solids	Probe: Hydrolab <sup>®</sup> Minisonde	0.1 mg/L*	Chesterfield County WQS
Temperature	Probe: Hydrolab <sup>®</sup> Minisonde	0.1 °C*	Chesterfield County WQS
Flow	USGS: Float	0.01 m/s	Chesterfield County WQS
Hardness	EPA 130.2	0.1 mg/L as CaCO <sub>3</sub>	Primary Laboratories
Total Ammonia	EPA 350.3	0.01 mg/L as N	Primary Laboratories
Nitrate/Nitrite	EPA 353.3	0.01 mg/L as N	Primary Laboratories
Dissolved Phosphorus	EPA 365.2	0.01 mg/L as P	Primary Laboratories
Total Phosphorus	EPA 365.2	0.01 mg/L as P	Primary Laboratories
Total Suspended Solids	EPA 160.2	1.0 mg/L	Primary Laboratories
Biochemical Oxygen Demand	EPA 405.1	2.0 mg/L	Primary Laboratories
Fecal Coliform	Standard Methods 9221 E.	2 MPN per 100ml	Primary Laboratories
<i>E. coli</i>	Standard Methods 9223 B.	1.0 MPN per 100ml	Primary Laboratories

\*When a method detection limit was not applicable for a parameter, it was replaced by an estimation of accuracy based on manufacturer's specifications.

Sampling for benthic macroinvertebrates followed the guidelines outlined in the Environmental Protection Agency's Revised Rapid Bioassessment Protocol (EPA, 1999). Monitoring occurred during the spring (March/April) since biological surveys at this time tend to yield a better recovery of large, near-mature invertebrates that are easier and more accurately identified. As in past years, sampling was conducted on a multi-habitat basis. A total of twenty jabs and/or kicks with a D-frame dip net were conducted along an approximate 100-meter sample reach relative to the proportion of represented habitat. Aquatic organisms entrained in the net were then separated from coarse particulate organic matter in the field by use of a series of sieve buckets. Large, easily identified



animals such as crayfish and vertebrates were noted on field sheets and returned to the stream. Samples were placed in double polyethylene freezer bags, labeled and preserved in the field with 95% ethanol.

Upon return to the laboratory, samples were stored at  $<4.0^{\circ}\text{C}$  in the laboratory refrigerator. Samples were washed through a #30 sieve with tap water to remove ethanol and placed in a white-bottomed tray. All visible benthic macroinvertebrates were removed from the debris, counted and placed in a labeled jar. Benthic macroinvertebrates were then sorted, identified to the lowest possible taxonomic level (most often genus) and enumerated using a 40x binocular microscope. Midge larvae (*Chironomidae*) were identified to family level rather than genus due to time and laboratory constraints. Sample composition was entered into EXCEL spreadsheets and metrics were calculated for each site.

### **Benthic Macroinvertebrate Metric Calculations and Analysis**

Seven benthic macroinvertebrate metrics first established by CH2M Hill (2000) form the basis of the assessment calculations. These metrics include:

- Total Taxa Richness (variety of different organisms present)
- EPT Index (summarizes the taxa richness of pollution-sensitive species)
- Percent Contribution of Dominant Taxon (a measure of community balance)
- Modified Hilsenhoff Biotic Index (assigns a single value from 0 to 10 to describe a benthic macroinvertebrate community's tolerance to organic pollutants)
- Percent Collector/Gatherers (Percent of the macrobenthos that "gather" food)
- Percent Predators (Percent of the macrobenthos within the predator functional feeding group)
- Percent Scrapers (Percent of macrobenthos that "scrape" their food from a substrate surface)

From 1999 to 2005, metric score development and refinement followed the protocol used by CH2M Hill (2000), USEPA (1999) and the USGS (1999). A trisectional approach was utilized where metric values were normalized into unit-less scores by separating metric value ranges into three categories assigned scores of "5", "3", or "1". Metric scoring criteria were derived from 1999 through 2005 reference site data (Swift Creek watershed) by using cumulative percentile analysis. The top scoring category, associated with the maximum score of "5", represented values equal to or exceeding the 75<sup>th</sup> percentile of reference sites scores for metrics that decreased in response to disturbance, or values less than or equal to the 25<sup>th</sup> percentile of reference sites scores for metrics that increased in response to disturbance. The low-end score, in this case "1", was likewise based on the 25<sup>th</sup> percentile (metrics that decrease with impairment) or 75<sup>th</sup> percentile (metrics that increase with impairment), for all sampling sites for a particular metric. The middle score of "3" encompassed the intermediate range. This produced a rather conservative index score (CH2M Hill, 2000). Table 3 outlines the results of the finalized 2005 scoring criteria refinement that was used for the analysis of the 2013 data.

Table 3. Finalized Bioassessment Scoring Criteria based on Swift Creek watershed benthic macroinvertebrate data 1999-2005.

Metric	Score		
	5	3	1
Total Taxa Richness	$\geq 31$	30 – 20	$\leq 19$
EPT Taxa Richness	$\geq 12$	11 – 6	$\leq 5$
% Dominant Taxon	$\leq 34.1$	34.2 – 56.4	$\geq 56.5$
Hilsenhoff Biotic Index (Modified)	$\leq 5.2$	5.3 – 5.9	$\geq 6.0$
% Gatherers	$\leq 51.4$	51.5 – 80.0	$\geq 80.1$
% Predators	$\geq 8.9$	8.8 – 2.5	$\leq 2.4$
% Scrapers	$\geq 7.4$	7.3 – 0.8	$\leq 0.7$

The final index score for a site was calculated by summing the individual metric scores and compared to the “perfect score” of 35 (7 metrics x “5”) to obtain a percent comparison value. From these comparison values cumulative percentile plots were generated to determine ranges for assigning impairment categories. A quadrisection approach was used based on upper and lower 10<sup>th</sup> percentiles and the median value to generate four impairment categories (Table 4).

Table 4. Finalized Evaluation Criteria for Chesterfield County Stream Biological Assessment established 2005.

Percent Comparable to		
Reference Condition	Biological Condition	Biological Attributes
$\geq 82.9 \%$	Non-Impaired	Comparable to the best attainable situation to be expected within the watershed
60.0 – 82.8 %	Slightly Impaired	Community structure and function less than expected
37.2 – 59.9 %	Moderately Impaired	Fewer species present, loss of intolerant forms, increase in tolerant taxa, reduction in EPT index
$\leq 37.1 \%$	Severely Impaired	Few species present. If high densities of organisms, then dominated by one or two taxa

It is of interesting note that the final evaluation criteria scores remained precisely the same from 2003 to 2005, reflecting the strength of the reference condition criteria. Finally, index scores derived from the metrics were calculated for each monitoring site and were then compared against the biological reference condition and described in narrative form based on the percent comparability and the criteria provided in Table 4.

“Best attainable” reference conditions were determined for each metric that could be applied to all streams of the county independent of stream order. For this, a series of linear regressions of each metric against stream order was performed to confirm that one reference scoring condition could be used (Table 5). Reference stream data from the Swift Creek watershed from 1999 through 2005 were included in this analysis to increase the sample pool. The resulting coefficients of determination ( $r^2$ ) values were then reviewed to identify any strong relationships that precluded the establishment of a single reference condition. Results of this analysis are outlined in Table 5 and indicate there were no strong relationships between metrics and stream order. As a result, all Swift Creek watershed sites were pooled together for development of the scoring criteria resulting in one reference condition.

*Table 5. Bioassessment metrics versus stream order, 1999-2005.*

Metric	$r^2$
Total Taxa Richness	0.0214
EPT Taxa Richness	0.0002
% Dominant Taxon	0.0141
Hilsenhoff Biotic Index (Modified)	0.0020
% Collector/Gatherers	0.0063
% Predators	0.0002
% Scrapers	0.0417

All metrics were analyzed using Pearson’s Correlation to determine if any redundancies existed. This procedure was first conducted by CH2M Hill in 1999 and was used to exclude metrics that were not unique. It was necessary to conduct this analysis again in 2002 and 2003 to reevaluate the metrics due to slight variances from CH2M Hill’s original taxonomic resolution. It was then conducted again in 2004 and 2005 to verify the relationships observed in the past. Following CH2M Hill (2000), any resulting Pearson’s correlation coefficient ( $r$ ) value  $> 0.90$  indicated redundant metrics. All of the metrics calculated in 2005 were below this threshold (Table 6). As in past reports, the greatest Pearson’s correlation coefficients were observed between total taxa richness and EPT taxa richness, and HBI index score and EPT taxa richness (Table 6).

Table 6. Bioassessment metrics redundancy matrix, spring 1999 to 2005. Values represent the Pearson's correlation coefficient (*r*).

	Total Taxa Richness	EPT Taxa Richness	% Dominant Taxa	HBI Index	% Gatherers	% Predators	% Scrapers
Total Taxa Richness	*	*	*	*	*	*	*
EPT Taxa Richness	<b>0.853</b>	*	*	*	*	*	*
% Dominant Taxa	-0.212	-0.190	*	*	*	*	*
HBI Index	-0.392	<b>-0.557</b>	0.158	*	*	*	*
% Collector/Gatherer	-0.227	-0.195	0.396	0.405	*	*	*
% Predator	0.273	0.166	-0.480	-0.039	-0.382	*	*
% Scrapers	0.060	-0.035	-0.165	0.024	-0.262	0.086	*

### Virginia Stream Condition Index (VSCI)

As in the past five years, the benthic macroinvertebrate data collected in 2013 was also analyzed using the stream condition index methodology developed by Tetra Tech, Inc for upland (non-coastal) streams in Virginia. This index has been described as “a primary indicator of ecosystem health” that can “identify impairment with respect to the reference or natural condition” (Tetra Tech 2003). The protocol was initially developed and tested with a comprehensive statewide data set of 1671 benthic macroinvertebrate samples collected from 1994 through 2002. The methodology was subsequently validated in 2006 with a probabilistic dataset using independent samples from 350 data reaches (VADEQ 2006) collected from 2001 to 2004. The index consists of eight core metrics, many of which are similar to those already used by the county. These metrics include:

- Total Taxa Richness (variety of different organisms present)
- EPT Taxa Richness (summarizes the taxa richness of pollution-sensitive species)
- Percent Ephemeroptera (proportion of pollution sensitive mayflies)
- Percent Plecoptera+Trichoptera - *Hydropsychidae* species (proportion of pollution sensitive stoneflies and caddisflies)
- Percent *Chironomidae* (proportion of pollution tolerant midge larvae)
- Percent Top Two Dominant Taxa (a measure of community balance)
- Modified Family Level Hilsenhoff Biotic Index (assigns a single value from 0 to 10 to describe a benthic macroinvertebrate community's tolerance to organic pollutants)
- Percent Scrapers (Percent of macrobenthos that “scrape” their food from a substrate surface)

The benthic macroinvertebrate sample composition was entered into EXCEL spreadsheets and the VSCI metrics were calculated for each site. For this exercise, family level taxonomic resolution was required and calculated for each metric score

determination. The final VSCI value was the mean of the eight separate calculated unit-less scores. From this VSCI value, “Aquatic Life Use Tiers” were discerned (Table 7) and compared to the county’s bioassessment determinations for compatibility in categorizing stream condition.

*Table 7. Virginia Stream Condition Index Aquatic Life Use Tiers (from VADEQ 2006) and comparable Chesterfield County Bioassessment Categories*

Index Score	Tier	Comparable Bioassessment Category
$\geq 73$	Excellent	Non-Impaired
60 – 72	Good	Slightly Impaired
43 – 59	Stress	Moderately Impaired
$\leq 42$	Severe Stress	Severely Impaired

### Habitat Metric Calculations and Analysis

The EPA’s Habitat Assessment for Low Gradient Streams has been used since 1999 to describe the instream and riparian characteristics of the monitored sites. This approach assigns scores to ten (10) individual parameters that are summed to obtain a final overall value. Worksheets detailing these parameters are completed in the field by two independent analysts. The resulting parameter scores of each analyst are subsequently averaged and summed. From 1999 to 2005, the averaged scores from the reference watershed (Swift Creek) were analyzed using cumulative percentile plots to determine ranges for assigning impairment categories for the county. A quadrisection approach was used based on upper and lower 25<sup>th</sup> percentiles and the median value to generate four impairment categories (Table 8). Total habitat scores obtained in 2013 were compared against these criteria.

### Quality Assurance/Quality Control

The Hydrolab<sup>®</sup> Minisonde multiprobe was calibrated using commercially prepared buffer solutions prior to deployment to the field. Specific pre-labeled bottles containing preservative provided by the contract laboratory were used to obtain samples. In all instances, sample collection and preservation followed protocols outlined in *Standard Methods*. Contract laboratory chain of custody forms were filled out in the field and signed by the appropriate parties upon delivery and receipt. Contract laboratory results were reviewed and data obtained was entered into an EXCEL spreadsheet. Results of contract laboratory QA/QC studies were provided and carefully reviewed. All records and field sheets were double checked for accuracy and archived in the Water Quality Section’s files.



Table 8. Finalized Evaluation Criteria for Chesterfield County Habitat Assessment established 2005.

Total Habitat Score	Category	General Habitat Attributes
$\geq 161$	Comparable to Reference	Stream substrate and instream cover optimal for the maintenance of the aquatic community; Channel flows naturally with strong sinuosity; Streambanks well vegetated and stable; Riparian zone wide and without impacts
147 - 160	Supporting	Stream substrate and instream cover sub-optimal; Channel exhibits slight modification and good sinuosity; Small amount of erosion present; Riparian zone slightly impacted
132 - 146	Partially Supporting	Stream substrate and instream cover marginal; Channel exhibits modifications and weak sinuosity; Moderate amounts of erosion present; Riparian zone substantially impacted
$\leq 131$	Non-Supporting	Stream substrate and instream cover poor; Channel exhibits extensive modification and poor sinuosity; large amounts of erosion present; Riparian zone heavily impacted

Unprocessed benthic macroinvertebrate samples were stored at  $\leq 4^{\circ}\text{C}$  in separate containers and labeled with site, date collected and collector's initials. Processed samples were stored in 95% ethanol in individual 60 ml jars labeled with site information, date processed, the date taxonomic identification was completed and analyst's initials. Benthic macroinvertebrate samples were processed carefully and double-checked for organisms prior to disposal of residual debris. Taxonomic keys and a reference collection were used to verify taxonomic identifications. Specimens of benthic macroinvertebrates added to the original reference collection and/or unknown taxa were brought to Virginia Commonwealth University's Aquatic Ecology Laboratory for taxonomic verification/identification. Data entry into the EXCEL spreadsheets for the benthic macroinvertebrates and habitat parameters was double checked for accuracy. Replicate samples were obtained for benthic macroinvertebrates and analyzed as individual samples for documentation of process precision and accuracy. Similarly, replicate habitat field sheets were completed and compared to initial assessments.

## **Results**

The following pages describe each site and contain a summary of the observations made during 2013. Field data sheets and associated notes are located in Appendix A following this report.

### **Direct Drainages to the Appomattox River**

The following pages summarize the findings during 2013 at four site established in 2012 that flow directly to the Appomattox River. Photos depict the upstream view of the site unless otherwise noted. Left and right banks are referenced from the perspective looking upstream.

## Site Number APR-01

Stream: Fleets Branch

Site: Virginia State University  
downstream of East River Road

Watershed: Appomattox River

Subwatershed: Fleets Branch

Approximate Drainage Area  
(acres): 198

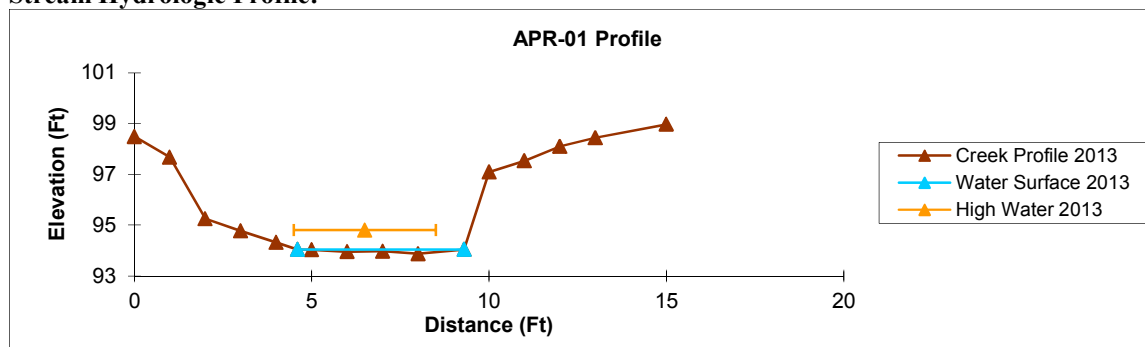
Stream Order: 1

Ecoregion: Deep Coastal Plain (4)

Landuse: Residential, University



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Severely Impaired” status. Total taxa richness (n=21) and EPT taxa richness (n=1) were low with 61.4 percent of the sample comprised of midge larvae (*Chironomidae*; n=742). Despite the depressed richness observations, the Hilsenhoff Biotic Index value (5.9) indicated a community comprised of a mix of pollution tolerant and pollution sensitive organisms. The large quantity of midge larvae and *Oligochaeta* (n=296) observed contributed substantially to the high proportion of collector/gatherers represented in the sample (89.6%). Predator (1.2%) and scraper (3.5%) taxa were observed in low to moderate proportions during 2013. Other taxa present in numbers included fingernail clams (*Pisidium*) and mosquito larvae (*Culicidae*).

### Habitat Assessment:

The habitat assessment score at this site was the lowest observed among all sites in 2013 and indicated a “Non-Supporting” condition for the reach. The streambed was comprised largely of cobbles with the epifaunal substrate metric returning a marginal value. Pool substrate was characterized by a mix of soft sand/sediment and the reach contained a preponderance of shallow pools. Sediment deposition was noticeable throughout the majority of the site’s length. The channel flow status was optimal. The reach exhibited historic channelization and as a result lacked strong sinuosity. Both stream banks exhibited obvious areas of scour/erosion down to bedrock in some areas and were sparsely vegetated. The riparian areas on either side were narrow with parking lots and university buildings present. An attempted buffer replanting was present along the right bank.

### Water Quality:

Concentrations of total ammonia (0.04 mg/L as N) and nitrate+nitrite nitrogen (0.19 mg/L as N) were slightly elevated. The levels of both dissolved (0.01 mg/L as P) and total phosphorus (0.05 mg/L as P) were low. Both the concentrations of nitrogen and phosphorus were significantly improved from the high degree of nutrient enrichment observed in 2012. The observed *E. coli* density (140.8 MPN/100ml) was improved over the observed 2012 violation of the VADEQ water quality standard for recreational contact. All other chemistries sampled were reflective of excellent water quality.

## Site Number APR-02

Stream: Stoney Creek

Site: Downstream of Trents Bridge Road

Watershed: Appomattox River

Subwatershed: Stoney Creek

Approximate Drainage Area (acres):  
606

Stream Order: 2

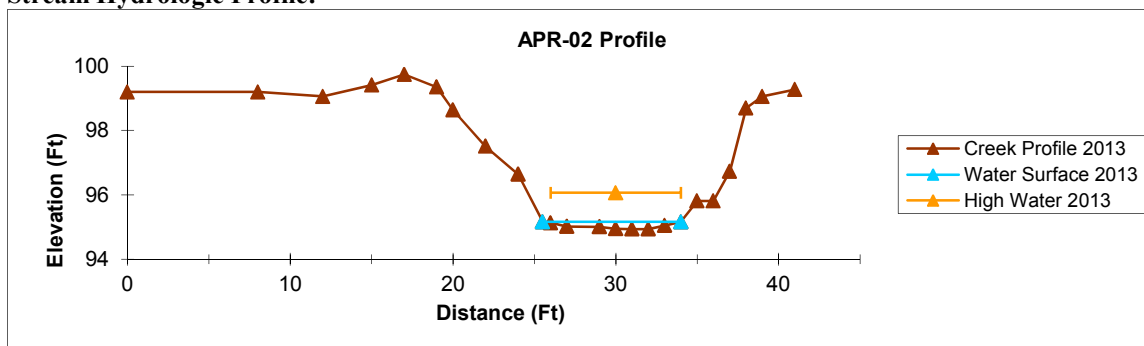
Ecoregion: Piedmont (5)



Landuse: Forest, Residential, Scout Camp

View is downstream

### Stream Hydrologic Profile:



### Bioassessment:

In 2013, the one of the two greatest bioassessment scores (88.6%) was observed at this site reflecting a “Non-Impaired” condition. Total taxa richness (n=34) was the best noted and EPT taxa richness (n=17) was the highest value observed among all sites. The community composition was well balanced with only 29.5% of the sample comprised of a single animal (*Chironomidae*; n=268); the lowest percent dominant taxa observed among all sites. The Hilsenhoff Biotic Index value (4.3) reflected a community comprised largely of pollution sensitive taxa. The proportion of collector/gatherers was 45.7% and the predator (8.4%) and scraper (2.6%) organisms were well represented. All metrics were suggestive of a fully functional and strong benthic community. Among other macroinvertebrates well represented were *Amphinemura* and *Perlesta* stonefly larvae, and *Acerpenna* mayfly larvae.

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited optimal substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of firm sand/gravel and the majority of the pools within the reach were large and deep. A slight degree of sediment deposition was observed along portions of the site. The channel flow status was optimal with water reaching the base of both banks but sinuosity was marginal. The stream was in its natural state with no recent or apparent alterations. Both banks were stable and well vegetated with only sparse areas of erosion noted. Riparian areas were completely undisturbed.

### Water Quality:

The concentration of total ammonia (0.01 mg/L as N) was significantly improved compared to 2012 when it was the highest concentration among all sites. Likewise, dissolved (0.01 mg/L as P) and total (0.05 mg/L as P) phosphorus concentrations were significantly improved from 2012. These nutrient decreases indicate an improvement in nutrient enrichment from the previous year. All other chemistries sampled were reflective of excellent water quality.



## Site Number APR-03

Stream: Tributary to the Appomattox

Site: Downstream of St. Audries Drive

Watershed: Appomattox River

Subwatershed: Lake Chesdin

Approximate Drainage Area (acres): 516

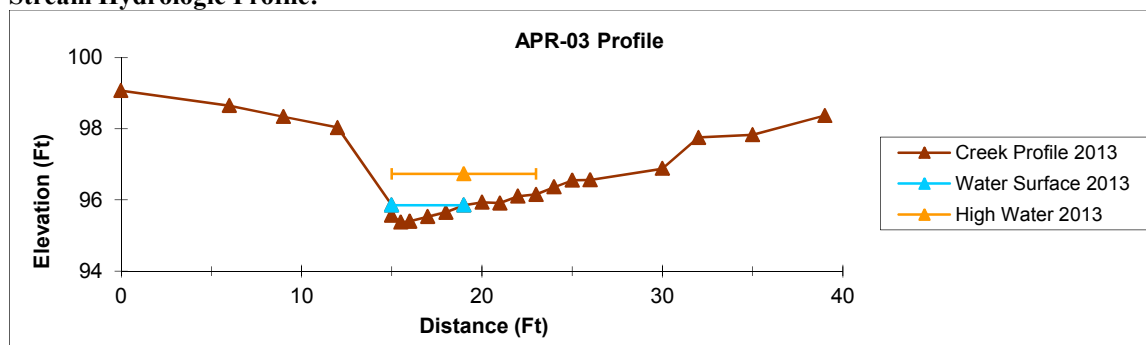
Stream Order: 3

Ecoregion: Piedmont (5)

Landuse: Forest, Residential



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Non-Impaired” status (88.6% comparable). Total taxa richness (n=31) was the second highest observed and EPT taxa richness (n=13) was excellent. Spiny Crawler mayfly larvae (*Ephemera*; n=436) accounted for 34.2% of the organisms recovered and the Hilsenhoff Biotic Index score was low (4.2), demonstrating a community comprised largely of pollution intolerant organisms. The large quantity of *Ephemera* and Chironomidae (n= 345) midge larvae observed contributed substantially to the proportion of collector/gatherers represented in the sample (69.8%). An excellent proportion of predators (11.2%) were observed due to strong numbers of biting midges (*Bezzia*) and *Haloperla* stonefly larvae. Scraper taxa, dominated by *Euryophella* mayfly larvae (n=76), were also well represented (11.4%) signifying a fully functional and strong benthic community.

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Comparable to Reference” condition and was the highest assessment among all sites. The stream reach exhibited optimal substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of firm sand/gravel and the majority of the pools within the reach were large and deep. A moderate degree of sediment deposition was observed throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations. Both banks were stable and well vegetated with only occasional sparse areas of erosion noted. Riparian areas were undisturbed.

### Water Quality:

All chemistries sampled were reflective of excellent water quality. Both dissolved (<0.01 mg/L as P) and total (0.05 mg/L as P) phosphorus concentrations were improved over the elevated concentrations observed in 2012 suggesting an improvement in water quality over the previous year.



## Site Number APR-04

Stream: Cattle Creek

Site: Downstream of Ivey Mill Road

Watershed: Appomattox River

Subwatershed: Cattle Creek

Approximate Drainage Area (acres):  
1528

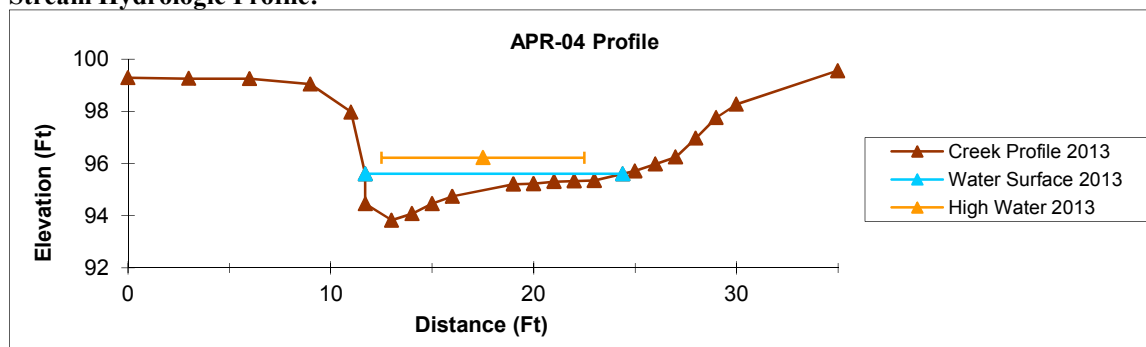
Stream Order: 3

Ecoregion: Piedmont (5)

Landuse: Forest, Residential



### Stream Hydrologic Profile:



### Bioassessment:

In 2013, the bioassessment at this site indicated a “Moderately Impaired” condition. Total taxa richness (n=32) was the second greatest observed at all sites and EPT taxa richness (n=10) was above average for the year. Midge larvae (*Chironomidae*; n=1234) accounted for 65.2% of the organisms recovered and the Hilsenhoff Biotic Index score was 6.2, demonstrating a community comprised largely of pollution tolerant organisms. Moderate percentages of collector/gatherer (77.5%) and predator (8.2%) taxa were present but a poor proportion of scraper organisms (1.4%) were noted. The benthic macroinvertebrate community was functional but not well balanced. Among the most abundant macroinvertebrates in the sample were fingernail clams (*Pisidium*), mosquito larvae (*Culicidae*) and Asian clams (*Corbicula*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. With a few exceptions, the overall reach habitat characteristics were very similar to site APR-02. The stream reach exhibited excellent substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of firm sand/gravel and the pools within the reach were a mixture of size and depth. A moderate degree of sediment deposition was observed throughout the site. The channel flow status was ideal with water reaching the base of both banks and sinuosity was marginal. The stream was in its natural state with no recent or apparent alterations. Both banks were stable and well vegetated with only sparse areas of erosion noted. Riparian areas were undisturbed. This reach’s riparian and bank structure scored highest among all sites.

### Water Quality:

All chemistries sampled were reflective of excellent water quality. Total ammonia (<0.01 mg/L as N), nitrate+nitrite (0.05 mg/L as N), and both dissolved (0.02 mg/L as P) and total (0.03 mg/L as P) phosphorus levels were low indicating minimal nutrient enrichment.

**Direct Drainages to the James River**

The following pages summarize the findings during 2013 at six sites established in 2012 that flow directly to the James River. Photos depict the upstream view of the site unless otherwise noted. Left and right banks are referenced from the perspective looking upstream.

Site Number JR-04

Stream: Spring Creek

Site: Downstream of Old Gun Road E.

Watershed: James River

Subwatershed: Spring Creek

Approximate Drainage Area (acres):  
847

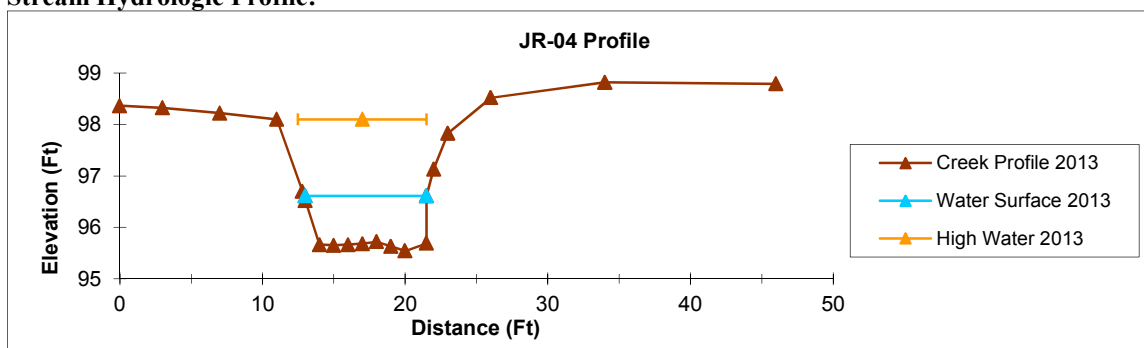
Stream Order: 2

Ecoregion: Low River Terrace and  
Alluvium (7)

Land use: Residential, Forest



**Stream Hydrologic Profile:**



**Bioassessment:**

The bioassessment in 2013 indicated a “Severely Impaired” status. Both the total taxa richness (n=14) and the EPT taxa richness (n=3) was low. *Amphipod scuds* (*Crangonyx*; n=194) accounted for 43.5% of the organisms recovered resulting in a moderate score for the percent dominant taxa metric. The Hilsenhoff Biotic Index score (6.8) was the highest observed among all sites; demonstrating a community comprised of pollution tolerant organisms. The large quantity of scuds combined with numerous midge larvae (*Chironomidae*; n=163) present contributed substantially to the high proportion of collector/gatherers represented in the sample (88.6%). Moderate proportions of predator (2.5%) and scraper (4.3%) taxa were observed. Other taxa present in notable numbers included segmented worms (*Oligochaetes*) and riffle beetle (*Stenelmis*).

**Habitat Assessment:**

The habitat assessment score at this site was the second lowest observed among all sites in 2013 and indicated a “Non-Supporting” condition for the reach. The streambed was comprised largely of fine silt/sand with the epifaunal substrate metric returning a marginal value. Pool substrate was largely mud and the reach contained a preponderance of large deep pools. Fine sediment deposition was prevalent throughout the site’s length. The channel flow status was optimal. The reach appeared to show evidence of historic channelization and as a result lacked strong sinuosity. Both stream banks exhibited obvious areas of scour/erosion and were sparsely vegetated. The riparian areas on either side were a combination of old and active agricultural fields (hay).

**Water Quality:**

The concentration of nitrate+nitrite nitrogen (0.57 mg/L as N) was elevated suggesting an upstream source of nitrogen enrichment. The dissolve oxygen concentration (6.9 mg/L) was the lowest observed among all sites. All other chemistries sampled were reflective of excellent water quality.

## Site Number JR-05

Stream: Tributary to the James

Site: Downstream of Ashwell Drive

Watershed: James River

Subwatershed: James River (4)

Approximate Drainage Area (acres):  
152

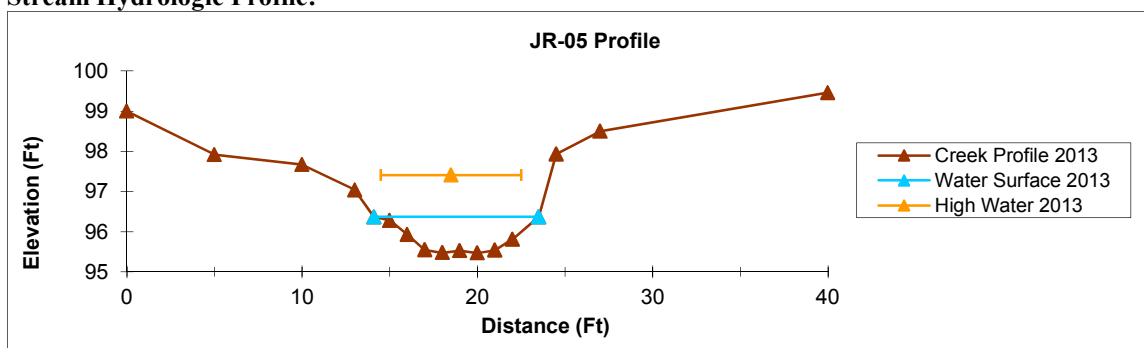
Stream Order: 1

Ecoregion: Low River Terrace and  
Alluvium (7)

Land use: Residential



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status. Total taxa richness (n=7) and EPT taxa richness (n=1) were both the lowest observed among all sites and this site had the fewest number of organism collected overall (n=87). The sample composition was dominated by finger nail clams (*Pisidium*, 32.2%). The Hilsenhoff Biotic Index score was high (6.3) indicating a community comprised largely of pollution tolerant organisms. A moderate percentage of collector/gatherers (42.5%) taxa were present and was the lowest observed percentage of collector/gatherers observed among all sites. The proportion of predator taxa present in the sample (0.0%) was the lowest percentage observed among all sites in 2013. The percentage of scraper taxa (14.9%) was the greatest among all sites in 2013 due to lunged snails (*Physella*) observed. The lack of predators and excess percentage of scrapers indicates a benthic macroinvertebrate community that is not well balanced.

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Non-Supporting” condition. The stream reach exhibited suitable substrate and instream habitat characteristics for the maintenance of the benthic macroinvertebrate community with gravel, cobble and exposed bedrock/boulders present. Pool substrate was comprised largely of firm sand/gravel and pool variability was suboptimal. Observed sediment deposition was minimal throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations aside from an upstream crossing. Both stream banks exhibited obvious areas of heavy scour/erosion and as a result were sparsely vegetated. A sanitary easement along the left bank and yards/homes along the right bank decreased the depth and quality of the riparian buffer areas.

### Water Quality:

Nutrient levels as measured by nitrogen and phosphorus species were low ( $\leq 0.05$  mg/L as N or P) suggesting minimal enrichment. The observed *E. coli* density (178.5 MPN/100ml) was the highest observed among all sites. All other chemistries sampled were reflective of excellent water quality.



## Site Number JR-06

Stream: Tributary to the James

Site: East of James River Road Drive

Watershed: James River

Subwatershed: James River (4)

Approximate Drainage Area (acres): 306

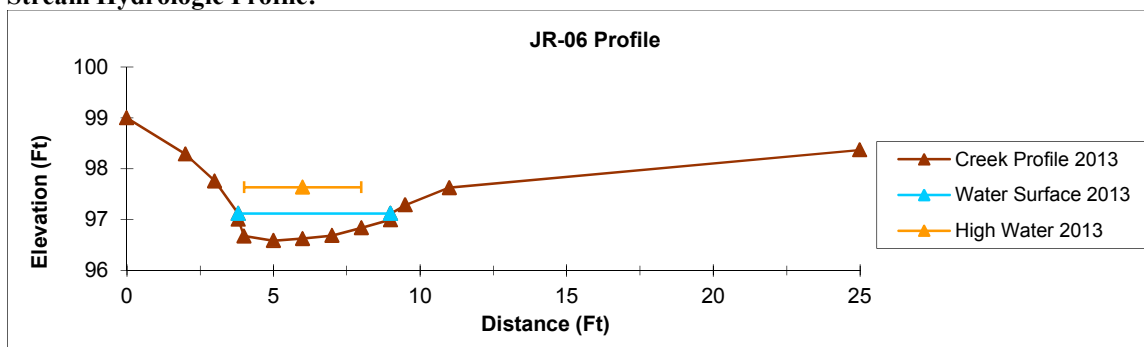
Stream Order: 2

Ecoregion: Low River Terrace and Alluvium (7)



Land use: Robious Landing Park, Residential

### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Severely Impaired” status. Total taxa richness (n=11) and EPT taxa richness (n=2) were among the lowest observed in 2013. Midge larvae (*Chironomidae*; n=42) were the dominant taxon (43.3%) and comprised nearly half of all macrobenthos collected (n=97). The Hilsenhoff Biotic Index score was moderate (5.9) indicating a community comprised of a combination of pollution tolerant and intolerant organisms. The large quantity of midge larvae observed in addition to numbers of segmented worms (*Oligochaetes*; n=39) contributed to the proportion of collector/gatherers (88.8%). The percentages of predator (2.1%) and scraper (1.0%) taxa were poor. The composition of the organisms was not reflexive of a well-balanced macrobenthic community. Other taxa recovered included Hydropsychid caddisflies (*Cheumatopsyche*) and Limnephilid caddisflies (*Ironoquia*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Non-Supporting” condition. The stream reach exhibited suboptimal substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of sand/gravel and the majority of the pools within the reach were shallow with some large and deep. Observed sediment deposition was visible throughout the site. The channel flow status was optimal and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations. Both stream banks exhibited obvious areas of heavy scour and erosion and as a result were sparsely vegetated. Riparian areas were largely undisturbed.

### Water Quality:

Nitrate+nitrite (0.08 mg/L as N) nitrogen levels were slightly elevated. Concentrations of dissolved (0.03 mg/L as P) and total (0.06 mg/L as P) phosphorus were low to slightly elevated. All other chemistries sampled were reflective of excellent water quality.



## Site Number JR-07

Stream: Tributary to the James

Site: West of James River Road Drive

Watershed: James River

Subwatershed: James River (4)

Approximate Drainage Area (acres):  
137

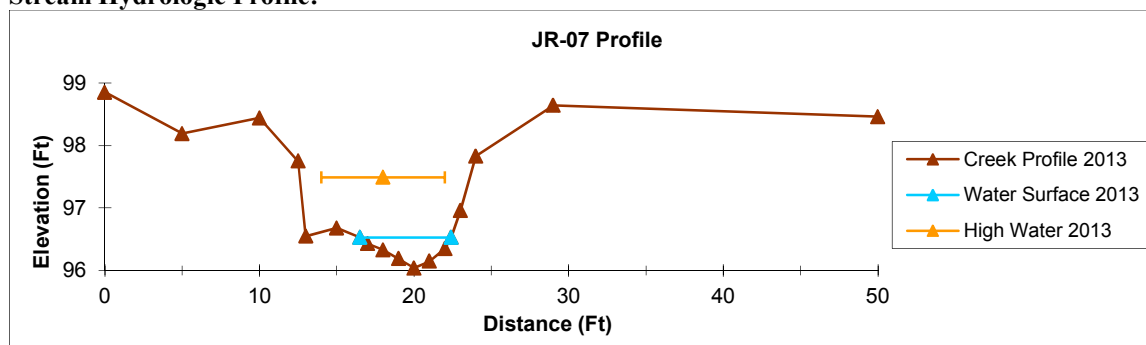
Stream Order: 1

Ecoregion: Low River Terrace and Alluvium (7)



Land use: Robious Landing Park, Schools

### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Severely Impaired” status. Total taxa richness (n=12) and EPT taxa richness (n=1) were low with 62.5 percent of the sample comprised of midge larvae (*Chironomidae*; n=343). The Hilsenhoff Biotic Index score was high (6.6) indicating a community comprised largely of pollution tolerant organisms. The large quantity of midge larvae observed in combination with numbers of scuds (*Crangonyx*; n=157) accounted for 91.1% of the sampled animals and resulted in the second highest proportion of collector/gatherers taxa observed among the sites (92.5%). The proportion of predator taxa present in the sample (2.6%) was low and the scraper taxa were poorly represented with a nearly equal the proportion observed (2.4%). Other taxa present included biting midge larvae (*Bezzia*) and Limnephilid caddisflies (*Ironoquia*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited excellent substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of mixed materials (firm sand/gravel/cobbles) and the majority of the pools within the reach were shallow. Observed sediment deposition was minimal throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was generally lacking. The stream was in its natural state with no recent or apparent alterations. Both banks were stable and well vegetated with only sparse areas of erosion and scour noted. Riparian areas were undisturbed.

### Water Quality:

Total ammonia (<0.01 mg/L as N) and nitrate+nitrite (0.05 mg/L as N) nitrogen levels were low. Concentrations of dissolved (<0.01 mg/L as P) and total (0.02 mg/L as P) phosphorus were low. These nitrate and phosphorus observations indicate minimal nutrient enrichment at this site. All other chemistries sampled were reflective of excellent water quality.

## Site Number JR-08

Stream: Marine Spring Branch

Site: Downstream of Kings Farm Drive

Watershed: James River

Subwatershed: Marine Spring Branch

Approximate Drainage Area (acres): 265

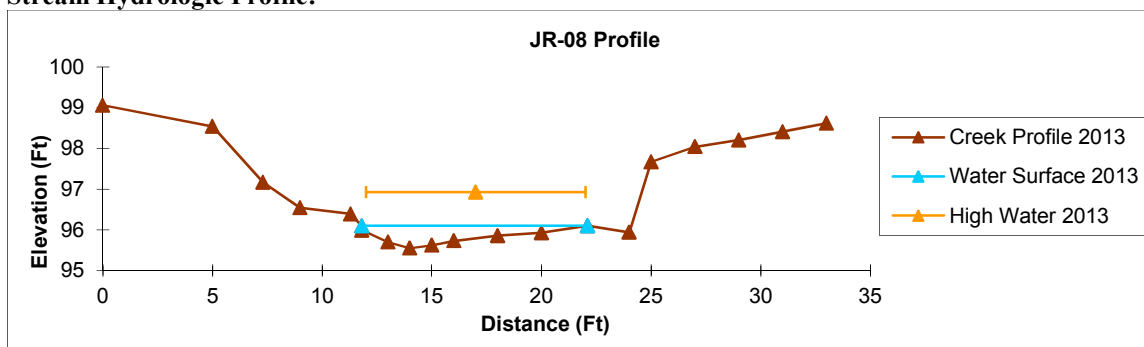
Stream Order: 2

Ecoregion: Triassic Basin (2)

Land use: Residential



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status. Total taxa richness (n=23) and EPT taxa richness (n=7) values were both moderate to low with midge larvae (*Chironomidae*; n=151) accounting for 39.0% of the organisms recovered. The Hilsenhoff Biotic Index score was high (6.1) demonstrating a community comprised primarily of pollution tolerant organisms. While the proportion of collector/gatherers represented in the sample (69.5%) was high, it returned an acceptable moderate score for that metric. Moderate proportions of predator (7.8%) and scraper (6.2%) taxa were also observed. Other taxa present in notable numbers included *Amphipod* scuds (*Crangonyx*), segmented worms (*Oligochaetes*) and fingernail clams (*Pisidium*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited suitable substrate and instream habitat characteristics for the maintenance of the benthic macroinvertebrate community with firm sand, gravel and cobble present. Pool substrate was comprised largely of an optimal mixture of bed materials and the majority of the pools were large and deep. Observed sediment deposition was minimal throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations aside from the upstream road crossing. Both stream banks exhibited obvious areas of heavy scour and erosion and as a result were sparsely vegetated. The riparian area depth along the right and left bank were decreased due to a residential development.

### Water Quality:

The concentration of nitrate+nitrite (0.53 mg/L as N) was elevated and reflected a source of upstream nitrogen enrichment. The concentrations of dissolved (<0.01 mg/l as P) and total (0.01 mg/L as P) phosphorus were low. All other chemistries were reflective of excellent water quality.

## Site Number JR-09

Stream: Roberts Branch

Site: Upstream of Crossings Way

Watershed: James River

Subwatershed: Roberts Branch

Approximate Drainage Area (acres):  
254

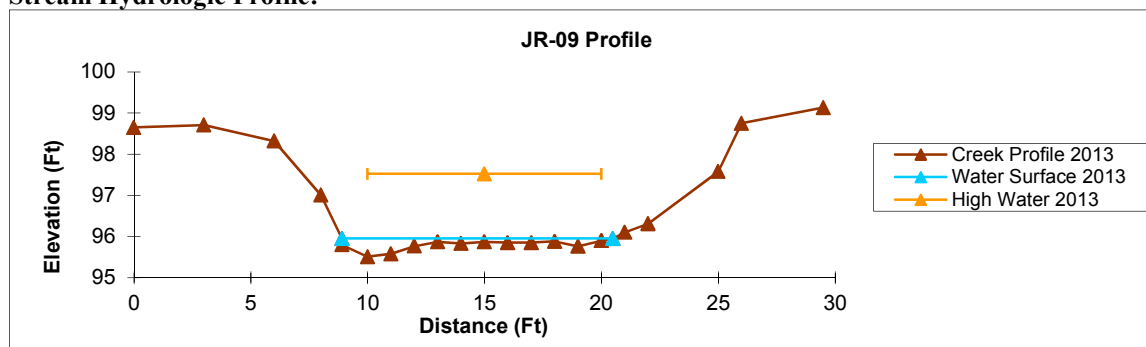
Stream Order: 2

Ecoregion: Triassic Basin (2)

Land use: Residential, Forest



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Slightly Impaired” status. Total taxa richness (n=22) and EPT taxa richness (n=8) values were both acceptable with midge larvae (*Chironomidae*; n=143) accounting for 66.7% of the organisms recovered. The Hilsenhoff Biotic Index score was moderate (5.9) demonstrating a community comprised of predominantly pollutant tolerant and some pollution sensitive organisms. The combination of midge larvae and segmented worms (*Oligochaetes*; n=58) composed the majority of the collector/gatherers present in the sample (66.7%). The proportion of predators (23.6%) was the greatest observed among all sites and can be primarily attributed to the quantity of biting midge larvae (*Bezzia*, n=68) collected. Scraper taxa were observed in low numbers (0.03%).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Partially Supporting” condition. The stream reach exhibited optimal substrate and instream habitat characteristics for the maintenance of the benthic macroinvertebrate community with firm sand, gravel and cobble present. Pool substrate was comprised largely of a mixture of bed materials and pool variability was excellent with a mix of deep and shallow pools. Observed sediment deposition was minimal throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was adequate. The stream was in its natural state with no recent or apparent alterations. Both stream banks exhibited obvious areas of scour and erosion and as a result were poorly vegetated. The riparian area along the right bank was in its natural condition and the depth along the left bank was decreased due to existing homes.

### Water Quality:

The concentrations of dissolved (0.04 mg/l as P) and total (0.08 mg/L as P) phosphorus were the highest concentrations of phosphorous in both categories observed in 2013. The concentration of nitrate+nitrite (0.17 mg/L as N) was slightly elevated. The phosphorous and nitrate observations reflected a potential source of upstream nutrient enrichment. The Biochemical Oxygen Demand at the sight was the highest observed among all sites (15 mg/L). All other chemistries were reflective of excellent water quality.

### **Michaux Creek Watershed**

The following pages summarize the findings during 2013 at five sites established in 2012 in the Michaux Creek Watershed. Photos depict the upstream view of the site unless otherwise noted. Left and right banks are referenced from the perspective looking upstream.



## Site Number MCX-01

Stream: Michaux Creek

Site: East of Route 288

Watershed: James River

Subwatershed: Michaux Creek

Approximate Drainage Area (acres):  
18

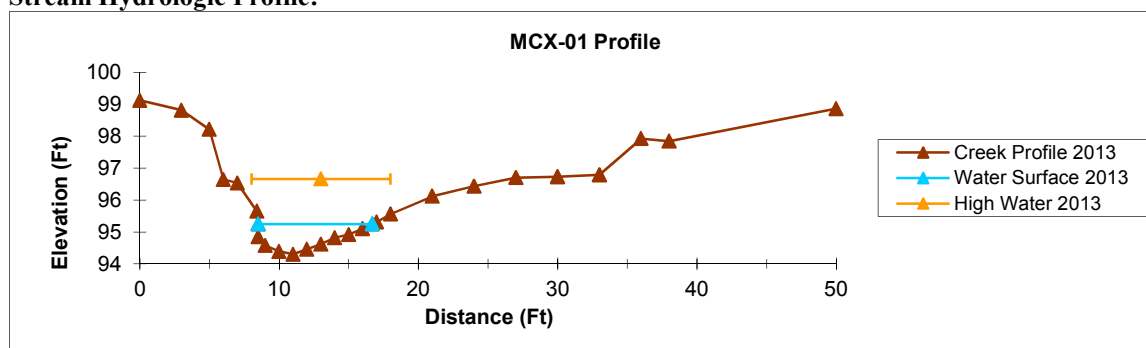
Stream Order: 3

Ecoregion: Triassic Basin (2)

Land use: Residential, Forest,  
Commercial



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status. Total taxa richness (n=24) and EPT taxa richness (n=9) values were both acceptable with midge larvae (*Chironomidae*; n=268) accounting for 66.8% of the organisms recovered. The Hilsenhoff Biotic Index score was moderate (5.5) demonstrating a community comprised of a mix of both pollution tolerant and pollution sensitive organisms. The quantity of midge larvae observed in combination with numbers of *Ephemera* (n=47) mayfly larvae, *Culicidae* (n=17) mosquito larvae and segmented worms (*Oligochaetes*; n=12) resulted in a high proportion of collector/gatherers present in the sample (86.3%). Moderate proportions of predator (6.0%) and scraper (2.5%) taxa were also observed.

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited excellent substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of an optimal mixture of bed materials and pool variability was excellent. There was a slight increase in sediment deposition throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations. Both stream banks exhibited obvious areas of heavy scour/erosion but with most areas well vegetated. Riparian areas were completely undisturbed.

### Water Quality:

The concentration of nitrate+nitrite (0.37 mg/L as N) was elevated suggesting a potential source of upstream nitrogen input. The concentrations of dissolved (<0.01 mg/L as P) and total (0.01 mg/L as P) phosphorus were both low. The rate of flow (0.44 m/s) through this stream reach was the highest observed among all sites. All other chemistries were reflective of excellent water quality.



## Site Number MCX-02

Stream: Tributary to Michaux Creek

Site: East of Route 288 & Upstream of MCX-01

Watershed: James River

Subwatershed: Michaux Creek

Approximate Drainage Area (acres):  
124

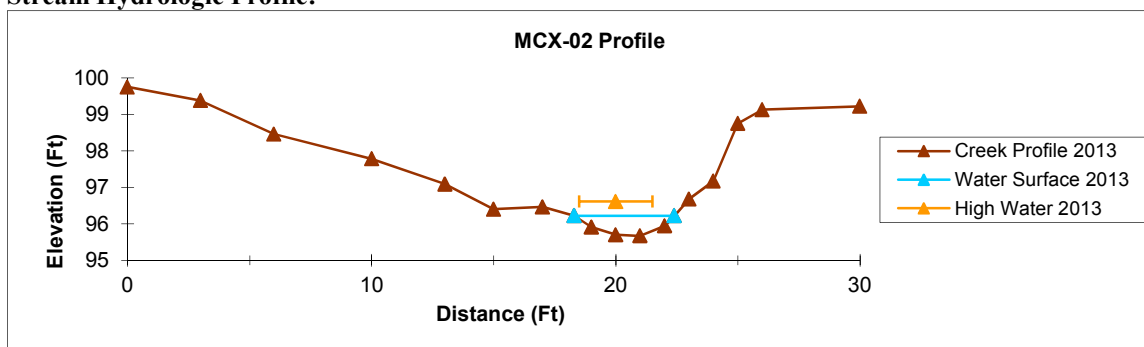
Stream Order: 1

Ecoregion: Triassic Basin (2)

Land use: Forest



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status; a two-tier decrease from the observed “Non-Impaired” status in 2012. Total taxa richness (n=26) and EPT taxa richness (n=11) were both moderate and the highest observed among the Michaux Creek watershed sites. The sample composition was dominated by *Ephemerella* mayfly larvae (57.3%). The Hilsenhoff Biotic Index value (3.3) was the lowest observed in 2013 and reflected a community comprised almost exclusively of pollution sensitive taxa. The proportion of collector/gatherers was high (81.7%); a reflection of the numbers of *Ephemerella* collected (n=811). The percentage of predator taxa (12.8%) was the second highest observed among all sites due to strong numbers of *Isoperla* (n=56) and *Diploperla* (n=43) stonefly larvae and biting midge larvae (*Bezzia*, n=48). Scraper organisms were represented in small proportions (0.4%). All metrics were suggestive of a functional benthic community. Among other macroinvertebrates well represented were midge larvae (*Chironomidae*, n=235).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited optimal substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised of a optimal mixture of sand and gravel and the majority of the pools within the reach were large and deep. A slight degree of sediment deposition was observed along portions of the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alterations. Both stream banks exhibited areas of erosion but with most areas well vegetated. Riparian areas were completely undisturbed.

### Water Quality:

The concentration of nitrate+nitrite nitrogen (0.33 mg/L as N) was elevated in 2013. All other chemistries sampled indicated excellent water quality.

## Site Number MCX-03

Stream: Tributary to Michaux Creek

Site: Southwest of North Otterdale Road

Watershed: James River

Subwatershed: Michaux Creek

Approximate Drainage Area (acres):  
46

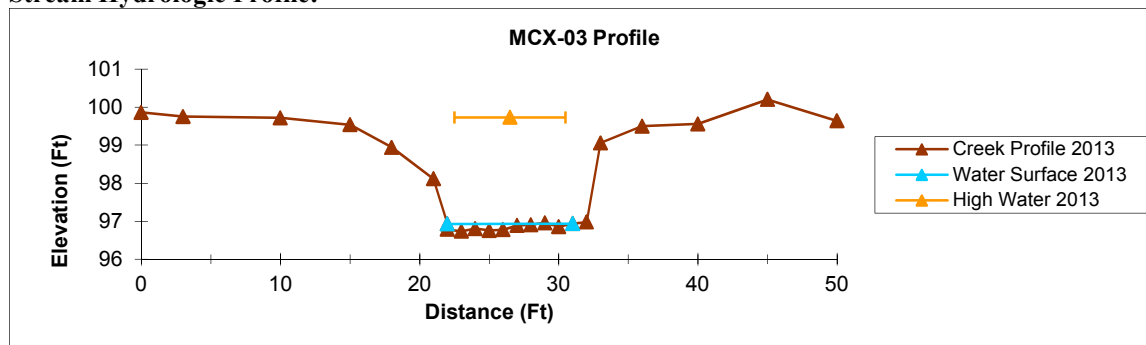
Stream Order: 1

Ecoregion: Triassic Basin (2)

Land use: Commercial, Forest



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status. Total taxa richness (n=13) and EPT taxa richness (n=3) were low with 69.9 percent of the sample comprised of midge larvae (*Chironomidae*; n=279). The Hilsenhoff Biotic Index score was high (6.0) and indicated a community comprised largely of pollution tolerant organisms. The large quantity of midge larvae observed contributed substantially to the high proportion of collector/gatherers represented in the sample (76.4%). The moderate proportion of predator taxa present in the sample (8.8%) was due to the quantity of biting midge (*Bezzia*) larvae recovered. Scraper taxa (9.0%) were represented in moderate proportions in 2013. Other taxa present in numbers included riffle beetles (*Stenelmis*) and segmented worms (*Oligochaetes*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. With a few exceptions, the overall reach habitat characteristics were very similar to sites MCX-01 and MCX-02. The stream reach exhibited borderline optimal/suboptimal substrate and instream habitat characteristics (e.g. non-embedded gravel/cobbles, snags and woody debris) for the maintenance of the benthic macroinvertebrate community. Pool substrate was comprised largely of a suboptimal mixture sand/gravel and the majority of the pools within the reach were large and deep. There was minimal sediment deposition present throughout the site. The channel flow status was optimal with water reaching the base of both banks and sinuosity was excellent. The stream was in its natural state with no recent or apparent alteration. Both stream banks exhibited areas of erosion but with most areas well vegetated. Riparian areas were completely undisturbed.

### Water Quality:

The calcium hardness value (66.2 mg/L CaCO<sub>3</sub>) was among the greatest observed in 2013 and indicated soft water. The greatest conductivity (368 µS/cm) and total dissolved solids (235.5 mg/L) measurements observed in 2013 were recorded at this site. The concentration of nitrate+nitrite nitrogen (0.50 mg/L as N) was elevated. All other chemistries sampled indicated excellent water quality.

## Site Number MCX-04

Stream: Tributary to Michaux Creek

Site: Downstream of Lasingham Drive

Watershed: James River

Subwatershed: Michaux Creek

Approximate Drainage Area (acres):  
481

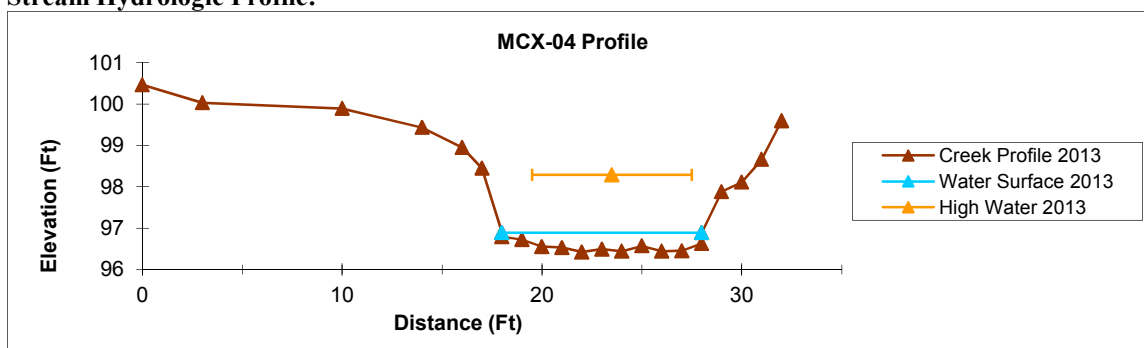
Stream Order: 2

Ecoregion: Triassic Basin (2)

Land use: Residential, Forest



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment at this site was the lowest scoring (20.0%) among all sites in 2013 and indicated a “Severely Impaired” status. Total taxa richness (n=15) and EPT taxa richness (n=4) were low with 88.4 percent of the sample comprised of midge larvae (*Chironomidae*; n=776). The Hilsenhoff Biotic Index score was high (6.0) demonstrating a community comprised of primarily pollution tolerant organisms. The large quantity of midge larvae observed in combination with numbers of segmented worms (*Oligochaetes*; n=40) resulted in the highest proportion of collector/gatherers present among all sites in the sample (96.7%). Low proportions of predator (1.9%) and scraper (0.1%) taxa were also observed. Among other macroinvertebrates well represented were mosquito larvae (*Culicidae*) and biting midges (*Bezzia*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Partially Supporting” condition. The stream reach exhibited suboptimal substrate and instream habitat characteristics for the maintenance of the benthic macroinvertebrate community with firm sand/gravel and cobble present along the length. Pool substrate was comprised largely of a suboptimal mixture of sand/gravel and the majority of the pools within the reach were large and deep. Observed sediment deposition was minimal throughout the site. The channel flow status was optimal with water reaching the base of both banks. The reach exhibited historic channelization and as a result lacked sinuosity. The stream was in its natural state with no recently apparent alterations aside from the upstream road crossing. Both stream banks exhibited areas of scour/erosion but with areas of partial vegetation. The riparian area depth along the right bank was decreased due to an existing sanitary sewer easement.

### Water Quality:

The concentration of nitrate+nitrite (0.99 mg/L as N) was the greatest value observed among all sites in 2013 and reflected a substantial source of upstream nitrogen enrichment. All other chemistries were reflective of excellent water quality.



## Site Number MCX-05

Stream: Michaux Creek

Site: End of North Otterdale Road

Watershed: James River

Subwatershed: Michaux Creek

Approximate Drainage Area (acres):  
1069

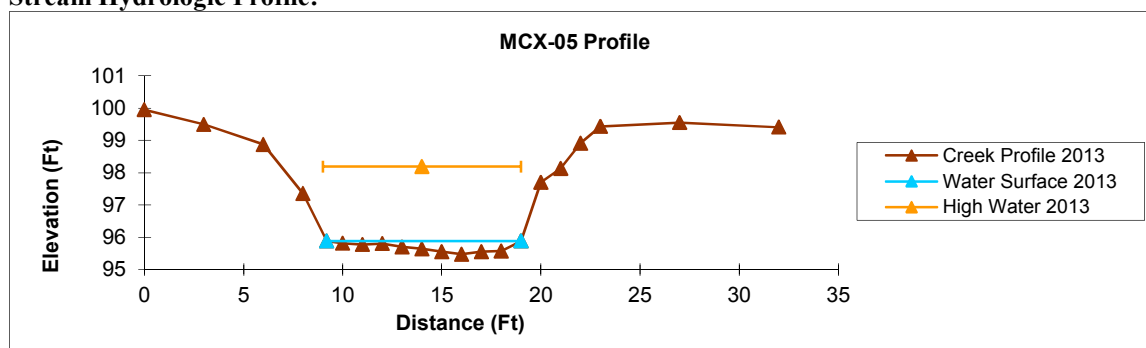
Stream Order: 3

Ecoregion: Triassic Basin (2)

Land use: Residential, Forest,  
Commercial



### Stream Hydrologic Profile:



### Bioassessment:

The bioassessment in 2013 indicated a “Moderately Impaired” status. Total taxa richness (n=23) and EPT taxa richness (n=5) were moderate to low with 66.8 percent of the sample comprised of midge larvae (*Chironomidae*; n=261). The Hilsenhoff Biotic Index score was moderate (5.8) indicating a community comprised of a mix of pollution tolerant and pollution sensitive organisms. The large quantity of midge larvae observed in combination with other organisms resulted in a moderately high proportion of collector/gatherers (79.3%). Moderate proportions of predator (4.9%) and scraper (6.6%) taxa were observed. Other taxon present in notable numbers included segmented worms (*Oligochaetes*).

### Habitat Assessment:

The habitat assessment in 2013 indicated a “Supporting” condition. The stream reach exhibited optimal substrate and instream habitat characteristics for the maintenance of the benthic macroinvertebrate community with firm sand/gravel and cobble present along the length. Pool substrate was comprised largely of a suboptimal mixture of sand/gravel and the majority of the pools within the reach were large and deep. Sediment deposition was minimal throughout the reach. The channel flow status was optimal with water reaching the base of both banks and sinuosity was adequate. The stream was in its natural state with no recently apparent alterations aside from an upstream road crossing. Both stream banks exhibited areas of scour/erosion but with most areas well vegetated. The riparian area depths along both banks were decreased due to the presence of a recent cutover along the left and the construction of a road along the right.

### Water Quality:

The conductivity (191  $\mu\text{S}/\text{cm}$ ) and total dissolved solids (120.1  $\text{mg}/\text{L}$ ) were the second highest measurements observed in 2013. The concentration of nitrate+nitrite nitrogen (0.12  $\text{mg}/\text{L}$  as N) was slightly elevated. The concentrations of dissolved (<0.01  $\text{mg}/\text{L}$  as P) and total (0.01  $\text{mg}/\text{L}$  as P) phosphorus were both low. All other chemistries were reflective of excellent water quality.

## Discussion

### Bioassessments:

A total of 11,827 individual benthic macroinvertebrates representing 82 distinct taxa were recovered in 2013. From this data set, the 20 most common taxa were identified and tabulated (Table 9). These 20 taxa combined accounted for approximately 94 percent of all organisms observed during 2013. Thirteen taxa were common with those listed in the 2012 report. These common taxa are presented in bold within Table 9.

Table 9. The twenty most common taxa observed throughout Chesterfield County, 2013. Bold taxa represent those common with 2012 assessments.

Number	Taxa	Common Name	Feeding Guild	n
1	<b>Chironomidae</b>	Midge Larvae	Collector/Gatherer	5647
2	<b>Ephemerella</b>	Spiny Crawler Mayfly	Collector/Gatherer	1555
3	<b>Oligochaeta</b>	Segmented Worms	Collector/Gatherer	765
4	<b>Crangonyx</b>	Scuds	Collector/Gatherer	539
5	<b>Bezzia/palpomyia</b>	Biting Midge Larvae	Predator	370
6	<b>Amphinemura</b>	Nemourid Stonefly	Shredder	293
7	<b>Pisidium</b>	Fingernail Clam	Filter/Collector	257
8	<b>Gammarus</b>	Scuds	Collector/Gatherer	233
9	Culicidae	Mosquito	Collector/Gatherer	195
10	<b>Stenelmis</b>	Riffle Beetle	Scraper	183
11	<b>Haploperla</b>	Green Stonefly	Predator	175
12	Eurylophella	Spiny Crawler Mayfly	Scraper	158
13	<b>Perlesta</b>	Common Stonefly	Omnivore	143
14	<b>Corbicula</b>	Asian Clam	Filter/Collector	98
15	Hydroporus	Predaceous Diving Beetle	Predator	95
16	Isoperla	Perlodid Stonefly	Predator	92
17	Siphonurus	Primitive Minnow Mayfly	Collector/Gatherer	80
18	<b>Acerpenna</b>	Small Minnow Mayfly	Shredder	78
19	Cambarus	Crayfish	Collector/Gatherer	72
20	Simulium	Blackfly Larvae	Filter/Collector	63

As in previous years, the overwhelming majority of organisms recovered belonged to the *Chironomidae* family of insects although it should be noted that many different genera of midge larvae were observed but not identified. The number of individual midge larvae collected (n=5647) represented approximately 48% of total individuals observed in 2013. The more pollution sensitive Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa collectively accounted for eight of the twenty most common taxa of benthic macroinvertebrates observed. Overall numbers of these taxa (n=2574) represented approximately 22 percent of all individuals recovered in 2013. The twenty most common

taxa reflected a general condition indicative of moderate water quality within these watersheds.

A summary of the bioassessment categories of the three monitored watersheds indicated that 80 percent of sites sampled (n=12) scored in the two lower categories during 2013 (Figure 1). Five sites were classified as “Severely Impaired” and seven were assessed as “Moderately Impaired.” One site in the James River watershed (JR-09) exhibited a “Slightly Impaired” bioassessment condition and two sites (APR-02 and APR-03) were assessed as “Non-Impaired” in 2013. The overall best bioassessment scores were noted in the Appomattox River watershed with the characterization of half of the sites as “Non-Impaired.”

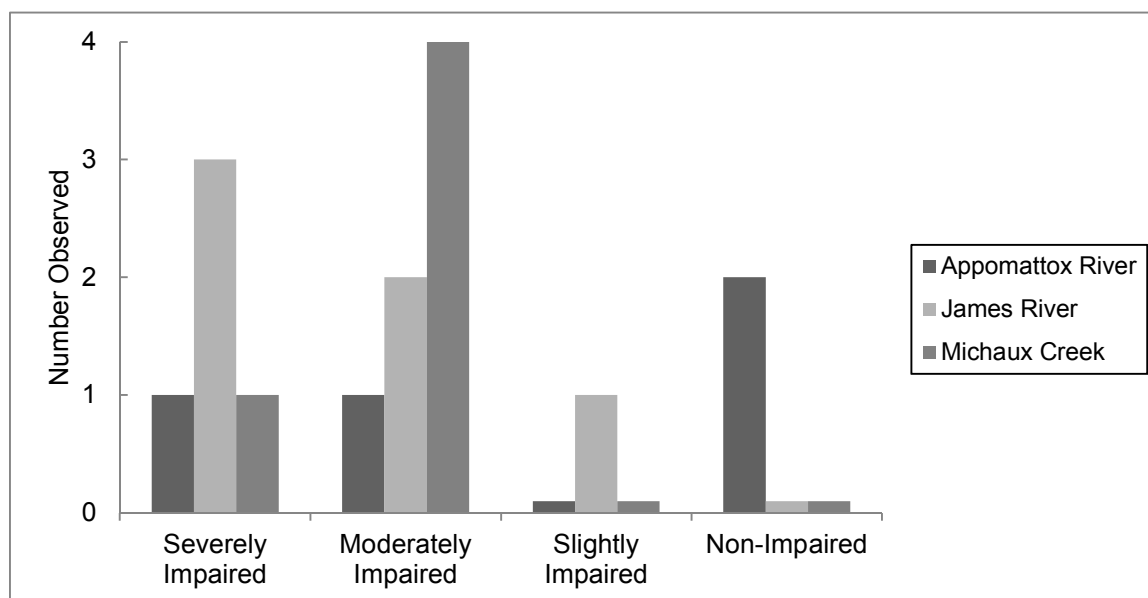


Figure 1. Categorical bioassessment observations in select watershed of Chesterfield County, 2013.

Four sites were investigated at small stream systems draining directly to the Appomattox River with bioassessment observations in three of the four categories (Figure 1). The best bioassessment scores observed in 2013 were noted within this data set with two of the four reaches assessed returning values of a “Non-Impaired” status. At these two sites, total taxa and EPT taxa richness values were among the best observed in 2013 indicating a wide variety of organisms. For the second consecutive year, the Stoney Creek (APR-02; “Non-Impaired”), benthic macroinvertebrate community was not dominated by a single organism and was comprised largely of pollution sensitive taxa. At Tributary to Appomattox River (APR-03; “Non-Impaired”), an increase in pollution sensitive taxa and total taxa richness and a decrease in the percent dominant taxon resulted in a two category improvement from Moderately Impaired in 2012. Both Stoney Creek and Tributary to Appomattox River had moderate or excellent percentages of collector/gatherer, predator and scraper taxa indicating a well balanced and functional benthic community.



The remaining two sites scored in the “Moderately Impaired” and “Severely Impaired” categories. Increased proportions of a single organism and pollution tolerant taxa were main factors influencing the score at Cattle Creek (APR-04; “Moderately Impaired”). Fleets Branch (APR-01; “Severely Impaired”) had a poorly structured community feeding guild, low EPT taxa richness, and single dominate taxon percentage were the basis of the stream’s depressed bioassessment score.

Six sites were investigated at stream systems draining directly to the James River with three reaches scoring as “Severely Impaired” and two as “Moderately Impaired” and one as “Slightly Impaired” (Figure 1). Within this data set, the better scoring “Slightly Impaired” site was the larger, named stream Roberts Branch (JR-09); this was an improvement over the 2012 scoring “Moderately Impaired.” At this site, total taxa, EPT richness, percent dominant taxon and the community pollution tolerance all scored a moderate ranking and the community was moderately populated with a mix of feeding guilds. The “Moderately Impaired” sites were a mix of a larger named stream, Marine Spring Branch, and a smaller unnamed stream, Tributary to the James (JR-05). The Tributary to the James (JR-05) assessment was an improvement over its score of “Severely Impaired” in 2012. The Tributary to the James (JR-05) had the lowest observed taxa and EPT richness observed in 2013 and the community was not well balanced being void of any identified predators. For all three sites, the Hilsenhoff Biotic Index metrics varied among the sites but were all in the low or moderate category demonstrating a general lack of strong representation of pollution sensitive taxa.

The remaining three reaches assessed within this data set were a mix of a named stream and un-named Tributaries to the James (JR-04, JR-06 and JR-07) and all scored in the “Severely Impaired” category. Spring Creek (JR-04) was listed as “Moderately Impaired” in 2012; therefore this is a decrease in ranking from last year. The score for both Tributaries to the James (JR-06 and JR-07) remained unchanged from 2012. Common characteristics at these sites included low total taxa and EPT taxa richness values and high proportions of midge larvae (*Chironomidae*) present in the sample. Hilsenhoff Biotic Index values were all high indicating a predominance of pollution tolerant taxa; the highest Hilsenhoff Biotic Index values calculated this year was at Spring Creek (JR-04). Feeding guild analysis demonstrated a large proportion of collector/gatherer organisms (>88%) and a general lack of predator and scraper taxa.

Five sites were assessed in the Michaux Creek watershed with one reach scoring as “Severely Impaired” and the remaining four scoring in the “Moderately Impaired” (Figure 1). The greatest change in bioassessment values was a decrease noted at un-named Tributary to Michaux Creek (MCX-02) which went from “Non-Impaired” (82.9% comparable) in 2012 to “Moderately Impaired” (54.3% comparable) in 2013. An increase in category was also noted at Tributary to Michaux Creek (MCX-03) from “Severely Impaired” to “Moderately Impaired.” At these four sites total taxa and EPT taxa richness values were acceptable and scored in the moderate range. With the exception of Tributary to Michaux Creek (MCX-02), the Hilsenhoff Biotic Index indicated a mix of pollution tolerant and pollution sensitive organisms with high proportions of midge larvae (*Chironomidae*) influencing the percent dominant taxon

metric negatively. The Hilsenhoff Biotic Index value at Tributary to Michaux Creek (MCX-02) was the best observed this year as a result of an unusually high number of *Ephemerella* mayfly nymphs (n=811) collected. At each of these four sites, the concentration of collector/gatherer organisms resulted in a high representation of this feeding guild within each sample while the predator and scraper taxa were present in moderate to low numbers.

The remaining site, Tributary to Michaux Creek (MCX-04), returned a bioassessment value indicative of a “Severely Impaired” condition. This bioassessment category is unchanged from 2012 but there was a decrease in comparability to reference from 37.1% to 20.0%, indicating that the stress on the benthic macroinvertebrate community is great. As with the other “Severely Impaired” sites previously discussed, common characteristics at this reach included low total taxa and EPT taxa richness values and high proportions of midge larvae (*Chironomidae*; 88.0%) present in the sample. The Hilsenhoff Biotic Index values was high indicating a general lack of pollution sensitive taxa and the proportion of collector/gatherer organisms (96.7%) was the highest observed among all sites.

*Table 10. Individual site comparisons of Chesterfield County bioassessment categories and the VSCI Aquatic Life Use Tiers, 2013.*

Site Number	Stream	Chesterfield County Bioassessment Category	Virginia Stream Condition Index “Aquatic Life Use Tier”	Comparison
APR-01	Fleets Branch	Severely Impaired	Severe Stress	Similar
APR-02	Stoney Creek	Non-Impaired	Excellent	Similar
APR-03	Trib to the Appomattox	Non-Impaired	Good	VSCI Lower
APR-04	Cattle Creek	Moderately Impaired	Stress	Similar
JR-04	Spring Creek	Severely Impaired	Severe Stress	Similar
JR-05	Trib to the James River	Moderately Impaired	Severe Stress	VSCI Lower
JR-06	Trib to the James River	Severely Impaired	Severe Stress	Similar
JR-07	Trib to the James River	Severely Impaired	Severe Stress	Similar
JR-08	Marine Spring Branch	Moderately Impaired	Stress	Similar
JR-09	Roberts Branch	Slightly Impaired	Stress	VSCI Lower
MCX-01	Michaux Creek	Moderately Impaired	Stress	Similar
MCX-02	Trib to Michaux Creek	Moderately Impaired	Good	VSCI Higher
MCX-03	Trib to Michaux Creek	Moderately Impaired	Severe Stress	VSCI Lower
MCX-04	Trib to Michaux Creek	Severely Impaired	Severe Stress	Similar
MCX-05	Michaux Creek	Moderately Impaired	Severe Stress	VSCI Lower

The benthic macroinvertebrate data set collected in 2013 was once again analyzed using the stream condition index methodology developed by Tetra Tech, Inc for upland (non-coastal) streams in Virginia. This Virginia Stream Condition Index (VSCI) was developed and tested with a comprehensive statewide data set and has been described as “a primary indicator of ecosystem health” that can “identify impairment with respect to the reference or natural condition” (Tetra Tech 2003). Further validation of this index was accomplished in 2006 using a probabilistic approach involving a database inclusive of 350 stations within the state (VADEQ 2006). Based upon these results, four “Aquatic

Life Use Tiers” were derived, each corresponding to a range of values and degree of impairment (Severe Stress, Stress, Good and Excellent).

Site comparisons were made using the VSCI score derived “Aquatic Life Use Tiers” and the Chesterfield County bioassessment conditions. During 2013, nine sites exhibited conditions where the VSCI and Chesterfield County bioassessment categories were similar (60%), five (33%) where the resulting VSCI condition was lower and one (7%) where the resulting VSCI index was higher (Table 10). A Pearson’s Correlation was used to determine the strength of the relationship between the Chesterfield County Bioassessment Score and the VSCI score within the assessed stream dataset. Analysis of 15 observations indicated that there was a statistically significant ( $p < 0.0001$ ,  $\alpha = 0.05$ ) and strong ( $r = 0.90$ ) positive correlation between these two methods. When the data from 2012 and 2013 are combined, a Pearson’s Correlation test yields a statistically significant ( $p < 0.0001$ ,  $\alpha = 0.05$ ) and stronger ( $r = 0.94$ ) positive correlation. This result further supports the argument that both approaches yield similar results in the determination of benthic macroinvertebrate stream condition in Chesterfield County. Continued evaluations of both methods will be conducted with the goal of eventually transitioning to using the VSCI exclusively for direct comparison to state programs.

## Habitat

A summary of the habitat categories of each monitored watershed indicated that the majority of sites (eight) assessed scored as “Supporting” in 2013 (Figure 2). Two sites were assessed as “Partially Supporting” and four demonstrated a “Non-Supporting” condition. One reach investigated scored a value indicating a “Comparable to Reference” status.

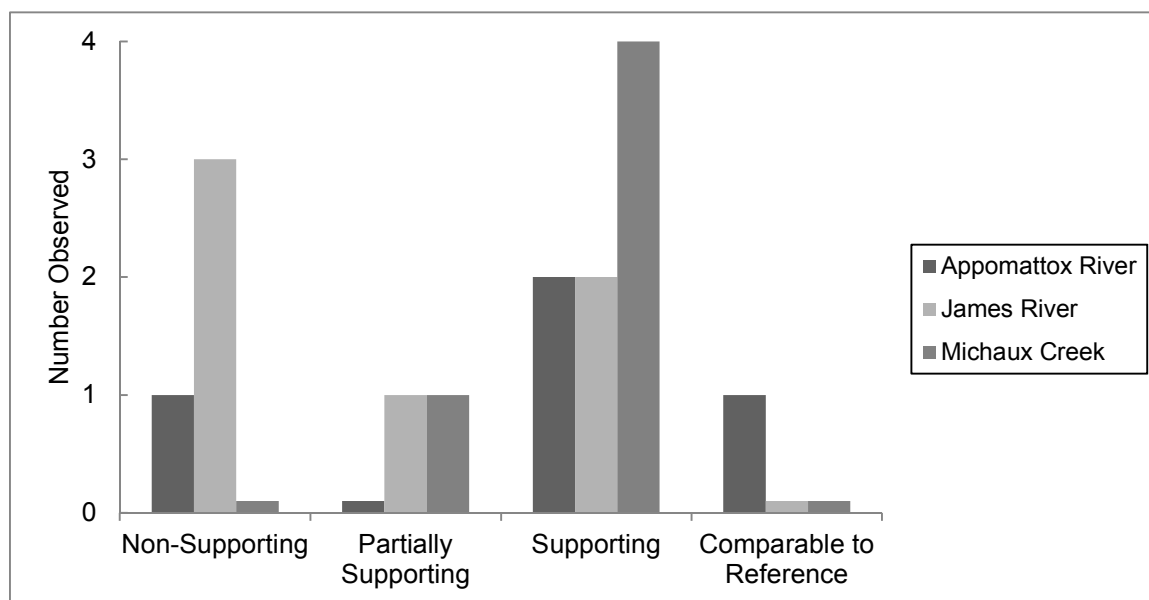


Figure 2. Categorical habitat assessments in select watersheds of Chesterfield County, 2013.

During 2013, Tributary to the Appomattox (APR-03), in the Appomattox River drainage indicated a “Comparable to Reference” habitat condition (Figure 2) an improvement over the 2012 assessment of “Supporting.” The Stoney Creek (APR-02) and Cattle Creek (APR-04), assessments indicated a “Supporting” habitat condition. The score assessments of these three streams varied by nine points or less indicating that while they are categorically different, the habitats are characteristically similar. Each of these streams is located in relatively undeveloped forested areas with some impact from large lot residential housing. The substrate and instream habitat in the form of non-embedded gravel/cobbles, snags and woody debris was prevalent in each of these streams, allowing for full colonization by the benthic macroinvertebrate community. Pools lacked significant sedimentation and were generally large and deep. Sediment deposition varied from minimal to moderate and flow within the stream reaches was excellent. These three streams were in their natural state, exhibiting varying degrees of sinuosity with no visibly recent alterations save for upstream road crossings present. Stream banks appeared stable and were well vegetated. Riparian areas were fully forested and undisturbed. The remaining Appomattox drainage reach assessed in this data set was located along Fleets Branch (APR-01) and bisected the Virginia State University campus. The habitat assessment score at this site was the lowest observed in 2013 and indicated a “Non-Supporting” status. Instream substrate and habitat was marginal, consisting of cobbles and gravel, pools were relatively shallow and filled with soft sediment. The reach exhibited historic channelization and lacked sinuosity. The stream was deeply incised with frequent areas of erosion and scour readily visible. As a result, the banks were sparsely vegetated. Both riparian areas were comprised of parking lots and academic buildings and a buffer replanting project was attempted along the right bank. Additionally, the presence of floatables/trash was noted throughout the reach and most likely the result of improper disposal by pedestrians that use the two stream bridge crossings.

During 2013, two of the six reaches assessed in the streams draining directly to the James River indicated a “Supporting” habitat condition, one indicated a “Partially Supporting” status and three were determined to be “Non-Supporting” (Figure 2). The sites that exhibited “Supporting” habitat were Tributary to the James (JR-07), located within the county’s Robious Landing Park and Marine Springs Branch (JR-08), located in the Riverdowns neighborhood. Common traits present at these two sites included good quality substrate and instream habitat, minimal sediment deposition, and excellent stream flow. “Partially Supporting” conditions were observed at Roberts Branch (JR-09) during 2013; unchanged from 2012. This site is affected by the presence of homes and yards impacting the riparian area. The stream habitat has suffered due to the presence of increased bank scour and erosion, loss of bank stability and decreased vegetative cover. As with previously observed sites in this watershed, these three reaches demonstrated suitable substrate and instream habitat, minimal sediment deposition, and excellent stream flow. For the second consecutive year, Spring Creek (JR-04), had the second lowest habitat assessment value recorded among all reaches observed and indicated a “Non-Supporting” condition. The Tributaries to the James (JR-05 and JR-06) were also assessed as “Non-Supporting;” a decrease for both sites from the previous year. Factors influencing the lower scores at these sites included marginal substrate and instream

habitat metric values, the stream banks exhibited obvious areas of scour and erosion, were sparsely vegetated and the riparian areas were heavily impacted by either development and human activities (JR-05 and JR-06) or historic and active agricultural fields (JR-04).

Four reaches in the Michaux Creek watershed exhibited a “Supporting” status and one site demonstrated a “Partially Supporting” status during 2013 (Figure 2). Two mainstem Michaux Creek sites (MCX-01 and MCX-05) and two un-named Tributaries to Michaux Creek (MCX-02 and MCX-03) reaches scored conditions indicative of “Supporting” habitat. Common characteristics at these four reaches included optimal substrate and instream habitat, strong flow and excellent sinuosity. In addition, stream channels at these sites were in their natural state with no recent or apparent alterations, and banks along both sides of the reaches were well vegetated. Riparian areas were completely forested and undisturbed with the exception of Michaux Creek (MCS-05). The habitat assessment at the remaining site, Tributary to Michaux Creek (MCX-04) indicated “Partially Supporting” conditions during 2013; unchanged from the previous year. Generally, substrate/instream habitat and channel morphology metrics scored well and were similar to the other sites in the watershed. The differences influencing the lower site assessments at this reaches was increased sedimentation and stream channelization and a distinct lack of channel sinuosity. Widespread stream bank erosion and scour were evident which resulted in poor vegetative cover. The riparian buffer area along the bank was impacted by a cutover sanitary sewer easement and neighborhood homes.

## **Chemistry**

A comprehensive suite of chemical parameters was collected during 2013. Supplemental screening for *E. coli* densities in the stream reaches continued to allow for comparison to current Virginia Department of Environmental Quality (VADEQ) water quality standards. Instream measurements of dissolved oxygen, pH, conductivity/total dissolved solids and temperature yielded values that were within Virginia state water quality standards and normally expected ranges for Chesterfield County during 2013. All dissolved oxygen concentrations were indicative of well-oxygenated waters with values ranging from 6.9 to 13.1 mg/L. Measurements of pH ranged from 6.2 to 7.3 units and temperature readings were normal for the season. No observations of conductivity were greater than 500 $\mu$ S/cm. Hardness measurements ranged from 13.0 to 66.2 mg/L as CaCO<sub>3</sub> and indicated “soft” water throughout the monitored watersheds.

Nutrient concentrations varied among sites and within watersheds during 2013 (Table 11). The median total ammonia value for all sites in 2013 was <0.01 mg/L as N with individual observations ranging from <0.01 mg/L as N at nine sites among all drainages to 0.04 mg/L as N at Fleets Branch (APR-01). Overall, the total ammonia concentration among the sites was significantly lower than the observations in 2012; the single greatest observation in 2013 (0.04 mg/L as N) was equal to the annual median observed in 2012. The median nitrate+nitrite nitrogen concentration for all reaches in 2013 was 0.17 mg/L as N, with individual measurements ranging from 0.02 mg/L as N at Stoney Creek (APR-02) to 0.99 mg/L as N at Tributary to Michaux Creek (MCX-04). A similarity among the



stream reaches with elevated nitrate+nitrite nitrogen concentrations ( $\geq 0.25$  mg/L as N) included immediate upstream dense residential or urbanized land use within their respective watersheds.

Measureable levels of dissolved phosphorus were observed at eight sites in 2013 ranging from 0.01 mg/L as P at three sites to 0.04 mg/L as P at Roberts Branch (JR-09). Seven sites had dissolved phosphorus concentration less than the detection limit indicating an overall decrease from last year when all sites had a measurable quantity. The median value observed for all sites assessed was 0.01 mg/L as P; decreased from the 2012 median 0.05 mg/L as P. Total phosphorus concentrations ranged from 0.01 mg/L as P at five sites distributed between the James River and Michaux Creek watersheds to 0.08 mg/L at Roberts Branch (JR-09). In 2013, the median total phosphorus value was measured at 0.02 mg/L as P. Overall, nutrient concentrations as measured by nitrogen and phosphorus were again elevated at the Fleets Branch (APR-01) site. The watershed of Fleets Branch is the most urban (dense housing and state university) of the current suite of assessment sites and this development most likely accounts for the increased nutrient input observations in addition to the visible impact to the surrounding habitat.

*Table 11. Observations of nutrients among 15 monitored sites in Chesterfield County, 2013. Greatest values observed for each parameter are in bold type.*

Site Number	Total Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Dissolved Phosphorus (mg/L as P)	Total Phosphorus (mg/L as P)
APR-01	<b>0.04</b>	0.19	0.02	0.07
APR-02	0.01	0.02	0.01	0.05
APR-03	0.02	0.03	<0.01	0.05
APR-04	<0.01	0.05	0.02	0.03
JR-04	0.02	0.57	<0.01	0.02
JR-05	<0.01	0.03	0.02	0.05
JR-06	<0.01	0.08	0.03	0.06
JR-07	<0.01	0.05	<0.01	0.02
JR-08	<0.01	0.53	<0.01	0.01
JR-09	0.02	0.17	<b>0.04</b>	<b>0.08</b>
MCX-01	0.01	0.37	<0.01	0.01
MCX-02	<0.01	0.33	<0.01	0.01
MCX-03	<0.01	0.50	0.01	0.02
MCX-04	<0.01	<b>0.99</b>	0.01	0.01
MCX-05	<0.01	0.12	<0.01	0.01

The levels of total suspended solids ranged from <0.01 mg/L at Tributary to the James River (JR-07) to 11.6 mg/L at Roberts Branch (JR-09). With the exception of the Roberts Branch (JR-09) site, all reach measurements conducted in 2013 were less than 10.0 mg/L. All sites appeared to run clear and were not visibly turbid at the time of assessment. Biochemical Oxygen Demand determinations conducted in 2013 were generally low with values ranging from <2.0 mg/L at eleven sites to 15.3 mg/L at the

Roberts Branch (JR-09). No BOD measurements observed in 2013 were indicative of severe organic enrichment.

Fecal coliform densities ranged from 7 MPN/100ml at Tributary to Michaux Creek (MCX-02) to 80 MPN/100ml at three sites: Tributary to the James (JR-07), Tributary to Michaux Creek (MCV-03) and Michaux Creek (MCX-05). These Fecal coliform results are improved over 2012 sampling when one of the sampling results was >1600 MPN/100ml. In 2013, *E. coli* determinations were continued as a supplement to the permit specified analyses to better compare bacterial impairment to current VADEQ water quality standards. The current recreation contact level of *E. coli* established by the VADEQ as of January 2011 is 235 CFU/100ml. The CFU or “Colony Forming Units” unit of measure specified by VADEQ is comparable to the Mean Probable Number or “MPN” designation used by the Chesterfield County contract laboratory. During 2013, none of the streams had *E. coli* measurements that were greater than the 235 MPN/100 ml state standards. The *E. coli* densities ranged from 13.5 MPN/100ml at Tributary to Michaux Creek (MCX-03) to 178.5 MPN/100ml at Tributary to the James (JR-05). Overall, these results are an improvement over the previous sampling year when three samples violated the state standard including Tributary to the James (JR-05).

### **Future Approaches**

In 2014, monitoring will continue at this set of stream reaches to gain further insight to their nature. The Virginia Stream Condition Index will continue to be calculated and will be further correlated with the current protocol with a goal of transitioning to its use for alignment with existing state programs. Supplemental *E. coli* densities will again be collected at each monitored site to allow for comparison to current Department of Environmental Quality water quality standards. Additionally, statistical analysis and correlation of the biological, habitat and chemical data will be conducted as needed in the hopes of establishing useful and mathematically valid predictive tools of water quality.

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